Unlicensed Operation in the TV Bands

ET Docket No. 04-186
ET Docket No. 02-380
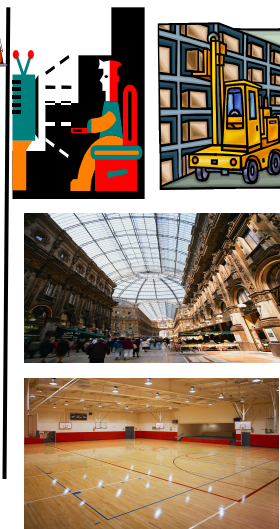

Use Cases

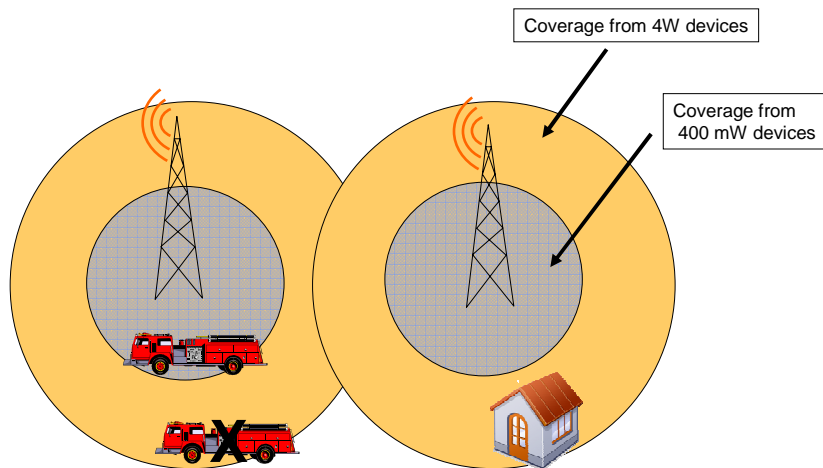**Low Density Outside**   **Temporary "fixed"**   **Low Density Inside**

2

4W Fixed Broadband to Homes

Coverage from 4W devices

3
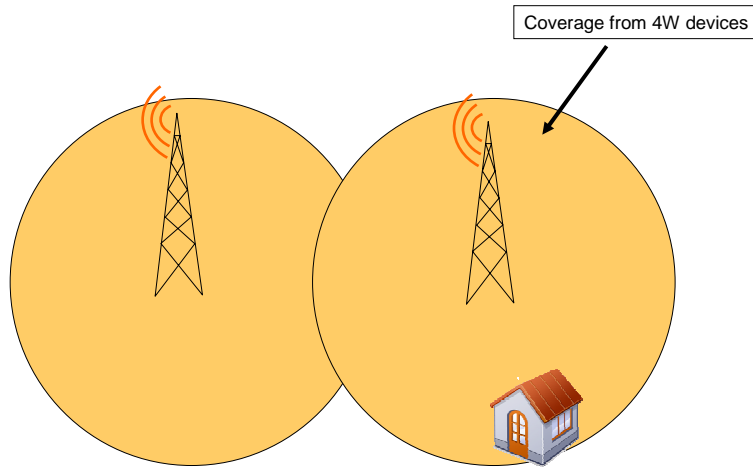
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Coverage with 400 mW Portables

Coverage from 4W devices

Coverage from 400 mW devices

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400 mW Portable Power Site Requirements
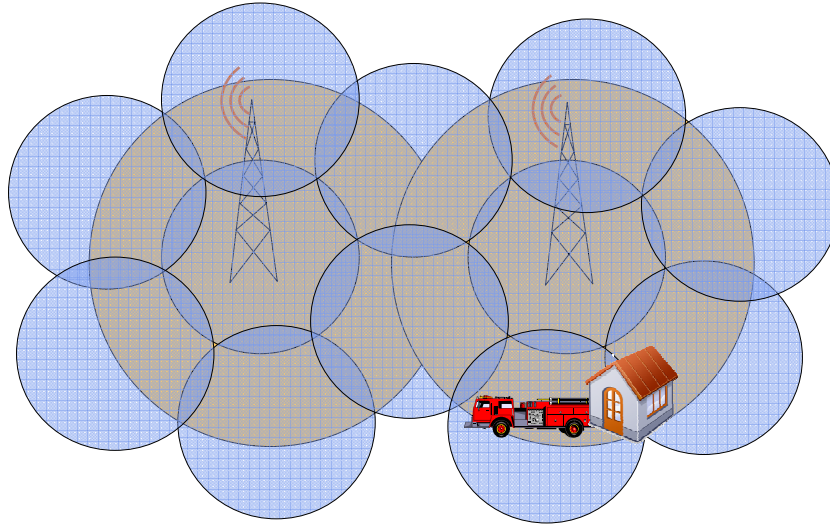
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Temporary Fixed Use Cases

Current rules support 4W at base operation

§ Fixed installation, relatively small number of sites, easy to monitor

§ Only has to react to infrequent changes in FCC TV station data base

§ At home transmitter could be 30 feet from another transmitter or TV

Possible rules for vehicles

§ 4W when position can be verified with database

– Extends range for more cost effective outside operation

– In most cases, vehicle would be farther from other transmitters and TVs than current fixed sites

– Cost effective to verify location, when outside, and validate against database

§ Most vehicle applications used while parked, so "temporary fixed"

§ Downloading of geo-location database can allow for some mobility

§ Revert to rules for portable power devices when location is unknown

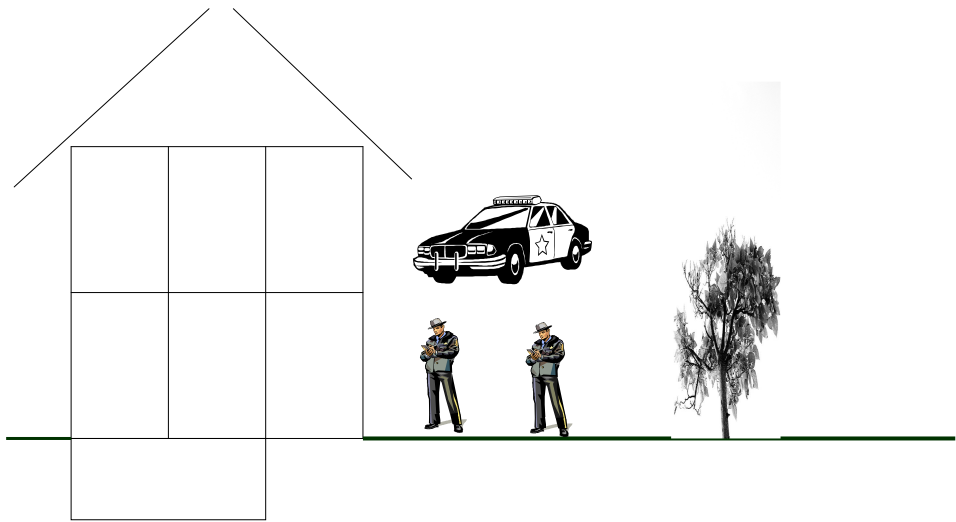– If sensing rules are adopted then use those rules for operation; if not discontinue operation

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Frequency Impacts
Obstacle Penetration

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Frequency Impacts
Obstacle Penetration

4.9 GHz

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Frequency Impacts Obstacle Penetration

4.9 GHz 2.4 GHz

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Frequency Impacts Obstacle Penetration

4.9 GHz 2.4 GHz 700 MHz

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Frequency Impacts
Obstacle Penetration

4.9 GHz   2.4 GHz   700 MHz   TV WS

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Unit-to-Unit Data (4.9GHz and 700MHz)

4.9 GHz   2.4 GHz   700 MHz   TV WS

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Unit-to-Unit Data (TVWS, 4.9GHz, 700MHz)

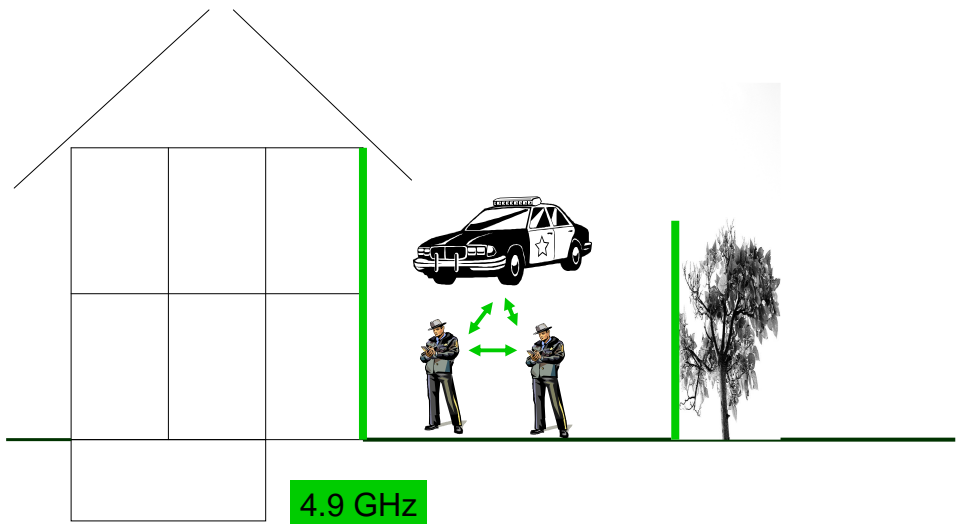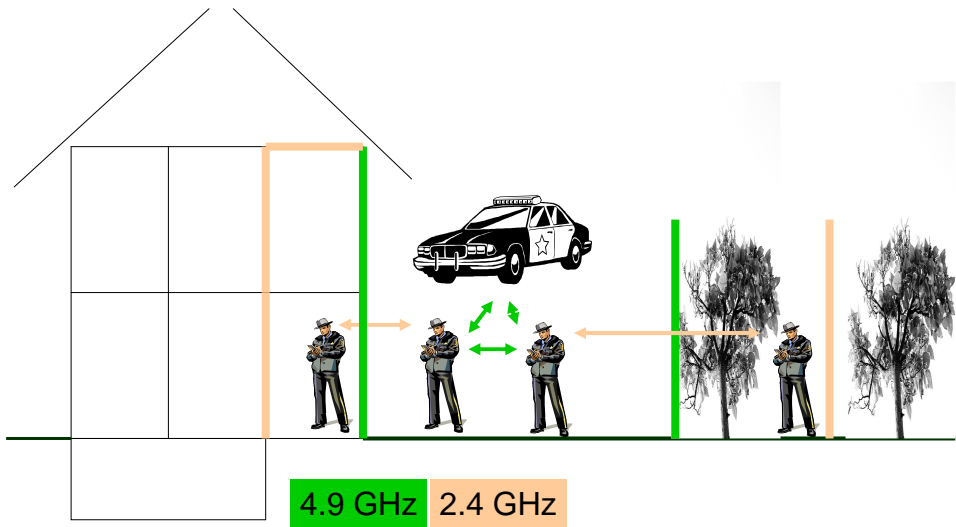4.9 GHz   2.4 GHz   700 MHz   TV WS

Incident Commander

April 2007
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Unit-to-Unit Data (TVWS, 4.9GHz)

4.9 GHz   2.4 GHz   700 MHz   TV WS
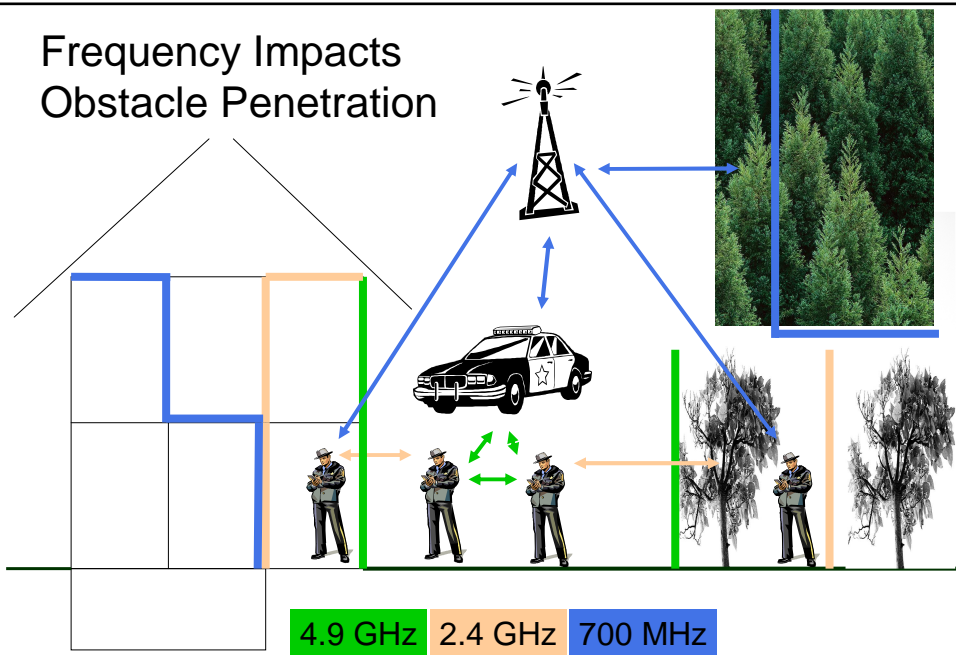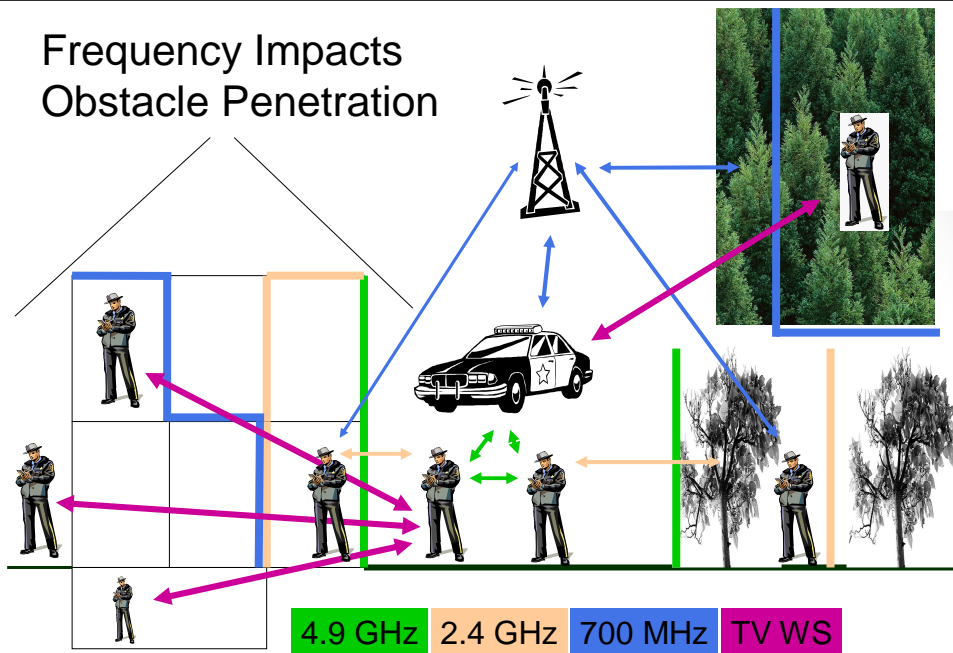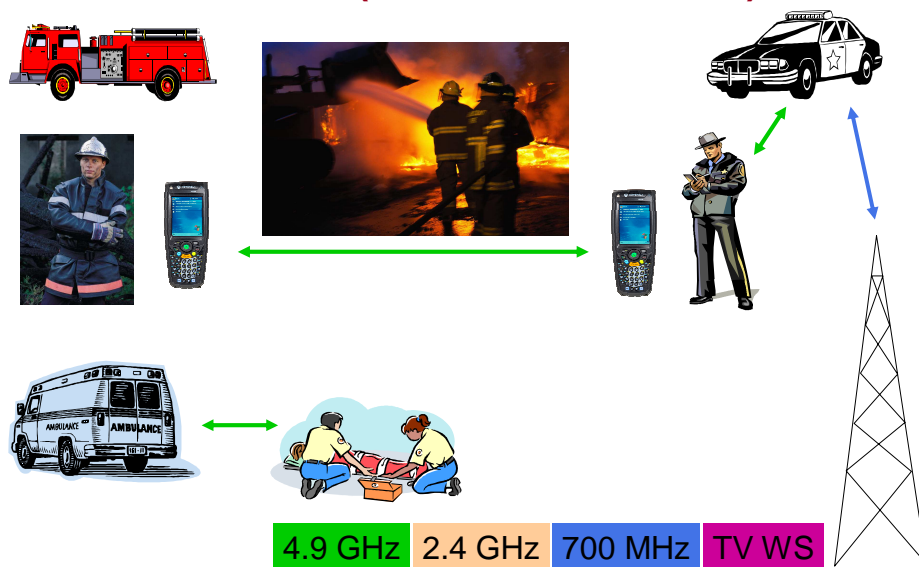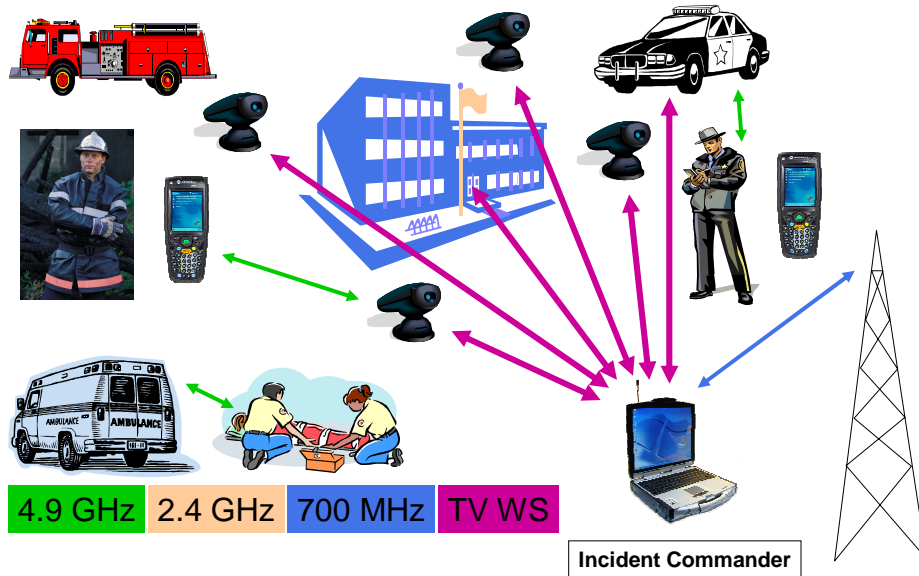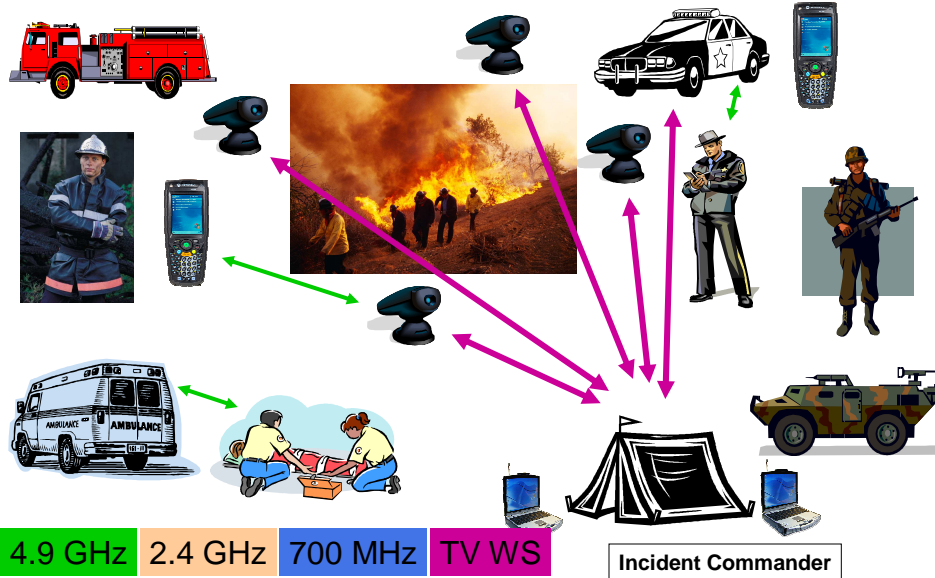
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Unit to Unit Broadband Data

Priority Pre-emption in Some TV White Space Meets Public Safety and Critical Users Needs

§ Incident scene use cases indicate only a few channels are needed

§ Cognitive rules would allow spectrum to be used by everyone when Public Safety and Critical Users were not specifically using it for their mission

§ With some guaranteed spectrum access, Public Safety and Critical Users could justify investment in devices and infrastructure to support more TV White Space applications, not just in pre-emptable spectrum

VHF would be ideal

§ Contained spectrum range for pre-emption rules

§ Best propagation

§ Requires bigger antennas; therefore more limited commercial applications and less usage

§ Unfortunately, noticeable parts of US have no available TV White Space in VHF

Some UHF would complement VHF

§ Recommend public safety and critical users have priority access on 2 UHF and 2 VHF channels in 7-25

§ Channels 26-51 would have no public safety and critical user pre-emption limitations

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Cognitive Radio /
TV White Space (TVWS) Demonstrations

Goals of Demonstrations:

§ Geolocation Database downloading and Creation of Interference Contour map

§ Reliability & Efficiency of Geolocation plus Sensing vs. Sensing alone

§ Fixed operation on prioritized channels

§ Incumbent Protection - Detecting (Sensing) and Avoiding DTV and Wireless Microphones

§ Feasibility of Personal / Portable (Mobile) Operation

§ Motorola Cognitive Radio demo shown at DySpan earlier this year
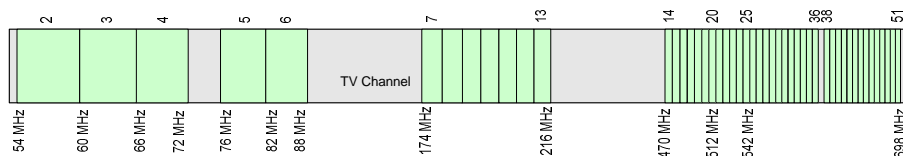
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Geolocation Database

Geolocation Database, as supplied by the FCC, can take at least two forms:

1. **Database of Transmitters, Antenna Types, Power, Direction**
   - § This would require radio device to calculate allowed channels at specific location
   - § This also enables additional algorithmic steps (prioritizing channels, etc.)

2. **Contour Maps**
   - § At what resolution?
   - § Are they sufficient?

Motorola prefers the first approach, as it offers more flexibility.

Chs 17-51 Available channels (>29dBm) 10m interf. rad.

Based on existing data base, not forecast post-transition.

Approximately 30 miles x 30 miles

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Geolocation Database

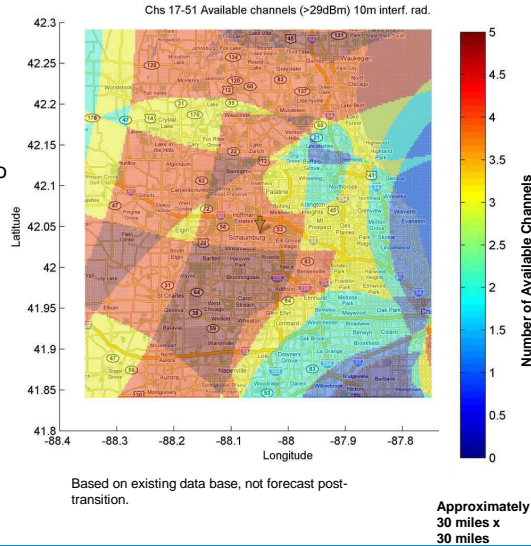**The database is usable *now***

There are holes in the data base that need to be filled

- § Some ERP, HAAT, RCAGL, service code, license status, and call sign data are missing or clearly wrong (e.g. HAAT or ERP = 0)

Rules should be codified as to which licenses must be considered for interference calculations

Interference prediction should rely on a specified propagation model

- § All unlicensed users should use the same model
- § Model needs to applicable to low antenna heights (e.g. two-ray model)

Machine-readable service contours would be useful for co-channel avoidance and user geo-location database compliance checking

- § However, location and propagation would still be needed to operate adjacent channel within a protected contour

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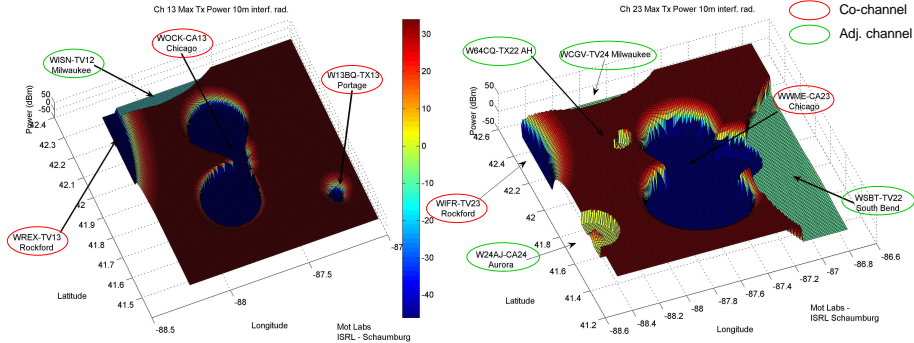
Location Database Examples
Max Allowed EIRP vs. Lat-Long Coordinates

Ch 13 Max Tx Power 10m interf. rad.

Ch 23 Max Tx Power 10m interf. rad.

Co-channel

Adj. channel

WISN-TV12 Milwaukee

WOCK-CA13 Chicago

W13BQ-TX13 Portage

WREX-TV13 Rockford

W64CQ-TX22 AH

WCGV-TV24 Milwaukee

WWME-CA23 Chicago

WSBT-TV22 South Bend

WIFR-TV23 Rockford

W24AJ-CA24 Aurora

Mot Labs - ISRL - Schaumburg

Mot Labs - ISRL Schaumburg

The charts show the Max allowed EIRP versus location coordinate for operation on TV channels 13 (left) and 23 (right) in the Chicago area

§ The color code indicates the allowed EIRP in dBm to satisfy various co- and adjacent channel interference criteria, taking into account the different protection requirements for different classes of licensed stations

§ Reddish-brown indicates >+30 dBm, dark blue <-45 dBm (essentially unusable)

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Control Signal – e.g. Enabling beacon

Control signal transmitter should have database access and propagation models

Control signal is an authorized operation but can occupy licensed, unlicensed, or whitespace spectrum

Portables would only operate on channels indicated as available by the control signal

Absence of a control signal would prohibit operation

Any device that is enabled by a control signal with geo-location information should be allowed to transmit with fixed-access privileges

Interference calculations should be based on the proximity of the most remote portables to the protected contours

§ Detection range of control signal + interference range of mobile

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Enabling Priority Access

Priority access *must be accounted for from the beginning* rather than trying to introduce it later, the FCC should prescribe a requirement for all Part 15 TV White space equipment

Beacons can be used to provide temporary priority access to the spectrum, e.g. public safety and critical users

§ Rights to transmit a beacon should be controlled in accordance to priority access requirements

Beacons should be thought of as an over-the-air, real-time data base supplement and not a signal to be 'sensed'

Motorola is actively involved in IEEE development of beacons

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Challenges: Sensing

Protection requirements cannot easily be redefined once unlicensed systems are fielded

§ Protected contour field-strength levels

§ D/U ratios

§ Propagation models

Licensed signals cannot be added or change their waveforms

Different licensed signals have different protection criteria but the same spectral signature

§ E.g. LPTV, translators, full-power TV (~10 -15dB difference between DTV and LP-DTV)

§ There are 11 DTV full power licenses, 16 LP-DTV/CPs/APPs, and 6 DTV STA UHF stations within 100 km of the Schaumburg, IL Motorola corporate headquarters, which would all have the same spectral signatures

– And 8 full power NTSC TV licenses, 7 class A, 4 translators, and 12 LP

§ Unlicensed devices that use licensed-like modulations (8VSB or FM) would get unfairly privileged access to the spectrum since sensing-only radios would defer to them

Very sensitive sensing receivers can be designed, but at the cost of spectrum availability for unlicensed use

Geo-location will provide the most efficient spectrum utilization with defined interference
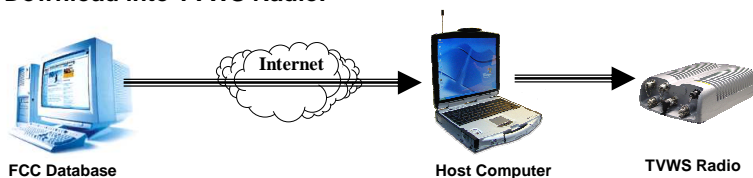
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Demo: Geolocation Database operation

The Host Computer will

1. **Be configured with approximate location,**
2. **Read Licensed TV Transmitter database from FCC server,**
3. **Calculate available TVWS channels per location within specified resolution,**
4. **Prioritize the available channels, based on power and other factors,**
5. **Display results, and**
6. **Download into TVWS Radio.**

Internet

FCC Database　　　　　　　　　　**Host Computer**　　　**TVWS Radio**

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Implementation Issues: Geolocation Database

Issues with Geolocation Database Approach:

- **~ 1 – 2 MB memory in radio device (if pre-computed) or computing power (if calculated real time)**

- **Accuracy, completeness and timeliness of data**

  - Timing of database updates vs. actual operation?

  - How often do devices need to access the database?
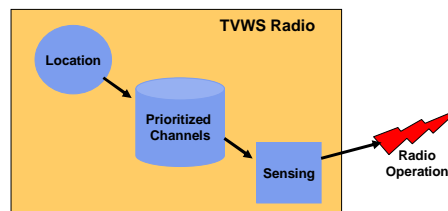
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Demo: Geolocation Database operation and Radio Start-up

The TVWS Radio Device will

1. Power up,
2. Determine location (from GPS, Manual Configuration, or other location mechanism),
3. Read the stored database of prioritized channels,
4. Select the highest quality channel (base channel),
5. Sense the channel and check that the base channel is OK (no Wireless Microphone),
6. Start operating

The TVWS Radio Device will be operating with an 802.11 protocol in 470-698 MHz, so operation will consist of sending periodic Beacons at this point (with only one radio operational).

Additionally, in step 5, if significant "interference" exists on the channel (i.e. some other system is using the channel), then it will be deprioritized and a new channel selected.
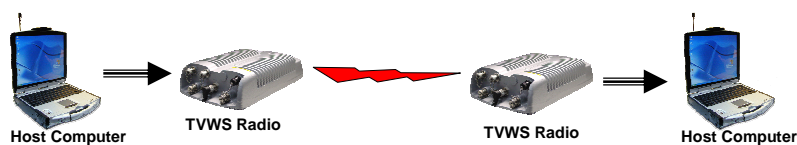
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Demo: Second Radio Start-up and Inter-Radio communications

At the second TVWS radio

1. Power up,
2. Scan non-prohibited channels for TVWS radio system beacon,
3. Validate and associate with TVWS system,
4. Receive updated channel list,
5. Start Video application, and
6. Stream Video from one host to another through radios.

Host Computer   TVWS Radio   TVWS Radio   Host Computer

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Demo: Detection of DTV Signal

Scenario: Presence of DTV signal

§ Periodically scan the operating channel to determine if a DTV signal is present.

§ Channel will be marked as used, and next highest priority channel will be utilized (backup channels are periodically scanned for the presence of licensed transmissions and prioritized accordingly).

1. Bring up an On-The-Air DTV transmitter, on the operational channel.
2. The Radio will detect the DTV signal within 10 seconds, and will vacate the channel within 2 seconds.
3. The TVWS system will move to an alternate channel.

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Demo: Operation while Mobile

Scenario: Mobility

§ Once a TVWS radio has moved beyond the local area, then it would be required to recalculate the allowable channel list/transmit powers based on the new location.

§ If the current operational channel is no longer preferred, the radio would have to vacate the channel with 2 seconds, in a procedure similar to that already outlined in the previous demo.

§ If the AP moves and results in new channel or change in allowed transmit power levels, it is signaled to all Clients to change transmit parameters.

§ If an AP can not determine its location (loss of reliable GPS signal, etc.), then it can not operate after a timeout.

§ If a MS can not determine its location but can hear a beacon (enabling signal) from a TVWS AP, then it can operate.

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Motorola Recommendations

No unlicensed operations in channels 14-20

Authorize public safety and critical users use of channels 14-20 on a "by rule" basis

Allow public safety and critical users unconditional priority access to 2-VHF and 2-UHF channels from TV channels 7-25

§ Beacons can be used as a mechanism for such priority access

§ The FCC rules must prescribe the reception of a disabling beacon to ensure priority

At this time it is not clear that sensing alone can be used for independent identification and protection of licensed incumbents

§ Support allowing use of personal / portable devices, such use would provide protection by a combination of spectral sensing and geolocation/database lookup.

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